A New Measurement of the ^{21}Na Beta-Decay Branching Ratio

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We are preparing to measure the branching ratio of the positron decay of ^{21}Na($\frac{3}{2}^+$) to ^{21}Ne($\frac{5}{2}^+$, 350 keV). This branch is $\sim$ 5% of the total decay rate, with the remainder going directly to the ground state ^{21}Ne($\frac{3}{2}^+$). The branching ratio was first measured in 1960 to be 2.2(3)% [1], but later measurements found larger, though inconsistent values[2, 3, 4, 5] (Fig. 1). The uncertainty in the branching ratio is currently a large systematic error in our ongoing studies of trapped ^{21}Na[6], and we hope to resolve the question with a new measurement using a radioactive ion beam.

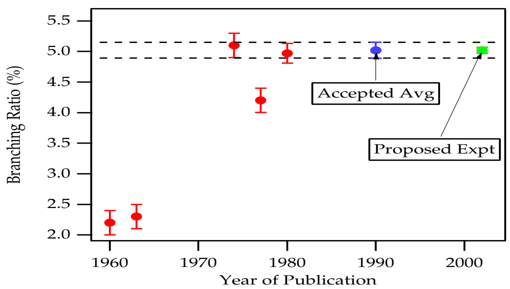

Figure 1: Previous branching ratio measurements

Previous measurements used similar techniques, producing ^{21}Na in a thick target and comparing the yields of 350 keV de-excitation gammas and 511 keV positron annihilation radiation which served as a measure of the total decay rate of ^{21}Na. This admits several sources of potential systematic error. The detector efficiency and integral number of counts at two different energies must be accurately determined, a task complicated by the fact that the Compton edge from 511 keV photons lies very near the 350 keV photopeak. In addition, other positron activities are produced in the target and must be accounted for. The inconsistencies in the previous measurements suggest that these systematic errors may not have been well controlled.

We plan a different approach which takes advantage of recent advances in radioactive beam production. We will use the ISAC facility at TRIUMF to produce a pure beam of ^{21}Na at $\sim 10^5$ pps and 1 MeV/u. The beam will stop in a thin foil of scintillator, enabling us to count the number of ^{21}Na nuclei deposited. We will use an HPGe detector to count the number of 350 keV photons. Because the beam is stopped in a thin foil, we should be able to shield the gamma detector from both positrons and annihilation photons produced elsewhere in the apparatus.

This scheme avoids some potential systematic errors associated with the earlier measurements; by using a mass-separated secondary beam we minimize contamination, and by counting the parent nuclei directly we no longer need to measure the number of annihilation photons, thus removeing one calibration requirement and allowing us to increase the signal to noise ratio of the 350 keV peak.

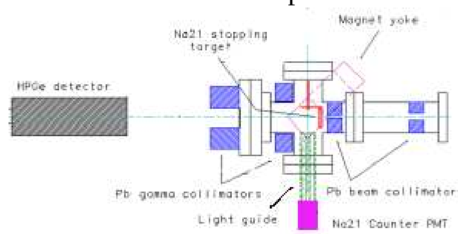

Figure 2: Experimental apparatus

Our proposal to TRIUMF was approved at the December PAC. Construction of the experimental apparatus is nearly complete, and we are fine-tuning the shielding and collimation. We hope to take data sometime during the summer of 2003.

References

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